

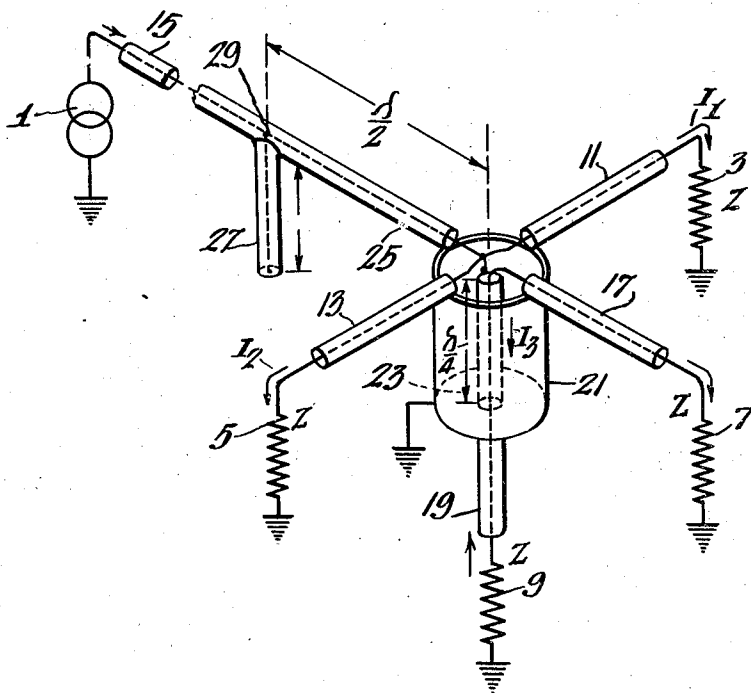
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RADIO POWER DIVISION NETWORK

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RADIO POWER DIVISION NETWORK

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This invention relates to radio frequency power dividing networks, such as are used to allocate the output of a transmitter between the various elements of a directional antenna array.

The principal object of the present invention is to provide an improved type of power division network, simple in design and construction and capable of providing efficient operation throughout a broad band of frequencies.

The invention will be described with reference to the accompanying drawing, which is a schematic perspective diagram of a structure embodying the invention.

A relatively common type of directive antenna array comprises four radiators, or groups of radiators, with their centers in line and spaced at equal intervals. Of the total power applied to the array, 10 percent is delivered to each of the outer radiators and 40 percent is delivered to each of the inner radiators. One array of this type is described in copending U. S. application Ser. No. 445,175, filed May 30, 1942, by G. H. Brown and entitled Antenna systems, now Patent No. 2,397,645, April 2, 1946.

It has been the practice to allocate the power between the inner and outer groups of such antennas by connecting the outer groups to the source through a network of resonant length transmission lines, so arranged as to cause the outer radiator groups to present to the source an impedance which is four times that presented by the inner radiator groups. The impedance mismatches introduced by this network are counteracted by means of matching stubs connected to the feed lines at suitable points and adjusted to eliminate standing waves thereon.

Systems of the above-described type operate satisfactorily, but only at the single frequency for which they are designed. At other frequencies the line sections of the network are no longer of resonant lengths, and the matching stubs are of incorrect lengths and improperly placed to function as intended, causing incorrect power division and generally inefficient operation of the system. In copending application Ser. No. 549,670 filed on Aug. 16, 1944, by G. H. Brown et al. and entitled Radio frequency power division network, it is proposed to divide the power between four loads in the required 1:4:4:1 ratios by connecting two of the loads in parallel to the input circuit and connecting the other two loads effectively in series with each other across the input circuit. One means for providing said series connection is described in said copending application. Resonant length line sections are

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also used in said system but means are provided for compensating variations with frequency of the reactances of said lines. However, variations in the resistive components of the impedances of the various elements are not compensated, and these components decrease progressively with variation in frequency from the center of the band through which the system is to operate. Although this variation in resistance does not disturb the power division ratio of the system, the efficiency is somewhat lower at the extremes of the frequency band than at the center.

The present invention relates to improvements over the system described in said copending application, whereby a simpler construction may be used, at the same time providing compensation for variation of resistance as well as reactance.

Referring to the drawing, a source 1 is to be connected to four loads 3, 5, 7 and 9 in such manner that the loads 3 and 5 each receive 40 percent, and the loads 7 and 9 each receive 10 percent of the output of the source 1. The loads 3, 5, 7 and 9 are represented in the drawing as resistors. It is to be understood, however, that they may be radiators or groups of radiators or in fact, any load devices. It is assumed that all of the loads are of equal impedance Z . The loads 3 and 5 are connected through coaxial lines 11 and 13 respectively in parallel with each other to a coaxial input line 15, extending to the source 1. The loads 7 and 9 are connected to coaxial lines 17 and 19 respectively. The outer conductor of the line 19 is surrounded at its input end by a tubular conductive sleeve 21, approximately one-quarter wavelength long at the center of the band of frequencies through which the system is to operate. The end of the sleeve 21 is closed by a conductive disc 23, connected to the outer conductor of the line 19 at a point one-quarter wavelength from the input end thereof. The other end of the sleeve 21 is connected to the outer conductors of the lines 11, 13, 15 and 17. The inner conductors of the lines 17 and 19 are connected together at their input ends.

The lines 11, 13, 17 and 19 are constructed so that their characteristic impedances are approximately equal to the impedances Z of the loads 3, 5, 7, 9. The sleeve 21 cooperates with the outer conductors of the final quarter wave section of the line 19 to act as a quarter wave line section short-circuited at its lower end by the disc 23. The diameter of the sleeve 21 is made as large as is conveniently practical, in order that the characteristic impedance of the short-circuited quarter wave line may be as high as possible.

Assuming that this impedance is four times the total resultant impedance of the loads 3, 5, 7 and 9, the final half wave section 25 of the line 15 is designed to have a characteristic impedance of approximately 44 percent of the impedance Z of one of the loads. A quarter wave line section 27 is connected across the line 15 at the point 29 one-half wavelength from the end thereof. The other end of the line section 27 is short-circuited. The line section 27 is designed to have a characteristic impedance equal to that of the quarter wave line formed by the sleeve 21 and the outer conductor of the line 19.

Current flowing from the source 1 through the line 15 is divided three ways: One portion I_1 flows through the line 11 to the load 3, an equal portion I_2 flows through the line 13 to the load 5, and a third portion I_3 flows down the outer conductor of the line 19, radially across the disc 23 and upward on the inner surface of the sleeve 21 to the outer conductors of the lines 11, 13, 15 and 17 all of which are at ground potential. The flow of current downward through the final quarter wave portion of the outer conductor of the line 19 induces an equal and opposite current to flow in the inner conductor of the line 19. This current flows through the loads 7 and 9 in series. Thus the loads 7 and 9 are effectively coupled in series with each other across the output end of the line 15, so that the current I_3 is one-half each of the currents I_1 and I_2 .

The impedance of the quarter wave line comprising the outer conductor of the line 19 and the sleeve 21 is also presented across the end of the line 15. It should be noted that this impedance will have no effect on the power division ratios, regardless of its value, since it shunts both pairs of loads. At resonant frequency, where the length of the line 19 enclosed by the sleeve 21 is exactly one-quarter wave, this impedance is substantially infinite with respect to the impedances of the loads 3, 5, 7 and 9. At other frequencies, however, the sleeve 21 provides a shunt reactance. This reactance is compensated by means of the one-half wave line section 25 and the quarter wave stub 27. It is found that if the characteristic impedance of the stub 27 is equal to that of the line formed by the sleeve 21 and the enclosed portion of the line 19 and is four times the total impedance presented to the output end of the section 25 by the loads 3, 5, 7 and 9, the impedance looking into the section 25 from the source will be constant throughout a wide range of frequencies, providing that the characteristic impedance of the line 25 is 1.1 times the resonant impedance of the loads 3, 5, 7 and 9. It is to be understood that the above ratios are given merely by way of example, and that other characteristic impedances may be employed with the half wave line section 25 to provide equivalent reactance compensation. For example, if the characteristic impedances of the short-circuited quarter wave lines were equal to the total load impedance, a half wave section 25 having a characteristic impedance 1.5 times that value would provide the optimum broad-band compensation.

The invention has been described as an improved power division network, in which two loads are connected in parallel to each other across an input line and two further loads are connected effectively in series with each other across said line by means of a coaxial line balance convertor. The resonant characteristics of the line balance convertor are compensated by means of a terminating half wave section on said input line

shunted at one end with a short-circuited quarter wave stub.

The invention covered herein may be manufactured and used by or for the Government of the United States for any governmental purpose without payment to me or assigns of any royalty thereon.

We claim as our invention:

1. A radio frequency power division network including a coaxial input line and two pairs of coaxial output lines, and a line balance convertor connected across said input line, the first of said pairs of lines being connected in parallel with each other to said input line, and one of said second pair of lines being connected through said line balance convertor to the other line of said second pair.

2. A radio frequency power division network including a coaxial input line, a pair of coaxial output lines with their input ends connected in parallel to the output end of said input line, a second pair of coaxial output lines with the input ends of their inner conductors connected together, the input end of the outer conductor of one of said second pair of lines being connected to the inner conductor of said input line, and a quarter wavelength sleeve surrounding said last-mentioned line, connected at one of its ends to the outer conductor of said last mentioned line, and at its other end to the outer conductors of all of the others of said lines.

3. A radio frequency power division network including a coaxial line substantially one-half wavelength long at the center of the band of frequencies over which the system is to operate, a pair of unbalanced-to-ground load circuits connected in parallel with each other across one end of said line, a line balance convertor comprising a quarter wavelength line section short-circuited at one of its ends and connected at its other end across said end of said half wavelength line, a second pair of load unbalanced-to-ground circuits connected in series with each other through said line balance convertor across said end of said line, and a second quarter wavelength line section short-circuited at one of its ends and connected at its other end across the other end of said half wave line.

4. The invention as set forth in claim 3, wherein said quarter wave line sections each have a characteristic impedance of $4Z$, where Z is the resultant impedance of all of said load circuits, and said half wave line section has a characteristic impedance of $1.1Z$.

5. A radio frequency power division network, including two pairs of coaxial transmission lines, and an input line, each line including an inner conductor and an outer conductor, with the inner conductor of said input line connected at a common point to the inner conductors of the first of said pairs of lines, and to the outer conductor of one of said second pair of lines; a sleeve surrounding the end portion of said last mentioned line, connected at one of its ends to the outer conductor of said last mentioned line and connected at its other end to the outer conductors of all of the others of said lines, and a connection between the inner conductors of the second of said pairs of lines.

6. A radio frequency power division network including a coaxial input line of characteristic impedance Z , four unbalanced loads, each of impedance $2.5Z$, a coaxial line section of characteristic impedance $1.1Z$ connected between the end of said input line and two of said loads in

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parallel, said line section being one-half wavelength long at the center of the band of frequencies over which the system is to operate, a quarter wavelength coaxial line section short-circuited at one of its ends and connected at its other end to the junction of said input line with said half wave line, said short-circuited quarter wave section having a characteristic impedance $4Z$, a second quarter wavelength coaxial line section of characteristic impedance $4Z$ short-circuited at one of its ends and connected at its other end to the other end of said half wave line section, the other two of said loads being con-

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nected in series with each other across the open end of said second quarter wave line section.

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REFERENCES CITED

The following references are of record in the file of this patent:

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